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TASTE PERCEPTION IN SMOKERS AND NON-SMOKERS

BY

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Taste is a complex sense. In addition to sensations arising in taste receptors, it is influenced by chemical, tactile, warm, and cold receptors in the mouth, and in particular by olfactory sensations (Houssay, 1955). It is presumably the complexity of the taste sense that has limited its objective study. The subject is, however, simplified by the generally held view that there are but four primary taste modalities: sweet, sour, salt, and bitter (Houssay, 1955; Best and Taylor, 1955; Fulton, 1955; Bell, Davidson, and Scarborough, 1959), and that odour plays no part in the recognition of these pure tastes.

Smoking is popularly held to decrease taste perception. This is attested by almost everyone subject to the habit, and particularly those who have mastered their addiction to it. There are, however, few objective studies on the effects of smoking on taste.

Bronte-Stewart (1956) discussed the relationship between smoking and ischaemic heart disease, and put forward the hypothesis that smoking could affect food preferences via the taste mechanism. To test this hypothesis, taste thresholds for sweet, sour, salt, and bitter in groups of smokers and non-smokers were determined and compared. Taste thresholds were similarly determined immediately before and immediately after the smoking of a cigarette in a sample of the above groups. In view of the findings, the relationship between the ability to taste phenylthiocarbamide (P.T.C.) and smoking was also examined.

Material and Methods

Two groups of subjects from different walks of life were tested in an identical manner a few weeks apart: (1) 80 medical students, 40 of whom were smokers—the mean age of this group was 20.5 (±3.1) years; and (2) 76 employees of a local insurance company, 39 of whom smoked, having a mean age of 27.6 (±9.3 years). Thus a total of 79 smokers and 77 non-smokers were tested. Tests were carried out over several days between 9.30 and 11 a.m. on each of these groups.

Test Procedure.—The subjects were asked to complete a questionary giving details of their age, sex, and smoking habits. They were informed of the aim of the experiment and of the taste modalities to be tested. They were told that there would be no fixed order in the substances to be tasted and that tap-water would be used from time to time. The observer recording the thresholds was kept ignorant of the smoking habits of the subjects. These tests were thus done in a "blind" manner. It was arranged that there were approximately equal numbers of smokers and non-smokers having threshold determinations on each day. Stepwise dilutions of sucrose (20–0.15%), citric acid (5–0.15%), sodium chloride (5–0.15%), and quinine hydrochloride (0.1–0.006%) were made up into solutions with tap-water. Each step in the titre series was a multiple of 0.5 of the preceding step. A single drop of a solution was deposited on to the centre of the protruded tongue by means of a pipette. The subject then withdrew his tongue, tasted the solution at leisure, and swallowed the drop. The threshold for each substance was determined in turn by depositing increasing concentrations of each solution, beginning with the most dilute. When two consecutive correct answers were given, the lower concentration was recorded as the threshold in each case. Mouths were rinsed with tap-water after each taste was identified. In this manner it was possible to determine the mean threshold value for each substance in each group of subjects.

Immediate Effects of Smoking.—Sixty of the above individuals, including 29 smokers, were subjected to a second series of tests. Initial threshold determinations were made as above, and the subject then went out for 10 minutes. The smokers all smoked a cigarette, while the non-smokers waited for a similar period until recalled. Each subject was then retested and thresholds were again determined.

Phenylthiocarbamide (P.T.C.). — Titres (0.13–0.00025%) were made up into solution in tap-water. Each step in the titre series was again a multiple of 0.5 of the preceding step. These threshold values were determined in the same manner as those above in 75 subjects, of whom 32 were smokers, drawn from both the student and the insurance groups.

Results

Thresholds for the Four Primary Taste Modalities.—The student group showed no significant differences between smokers and non-smokers in the mean taste thresholds for sweet, sour, or salt. The mean threshold for bitter, however, was significantly higher ($P<0.001$) in the smokers than in the non-smokers. These findings

were exactly reproduced in the insurance group of subjects. Neither age nor sex variables between the groups account for this finding (Table I). Thus in two separate groups it was shown that smokers taste bitter less well than non-smokers (Fig. 1).

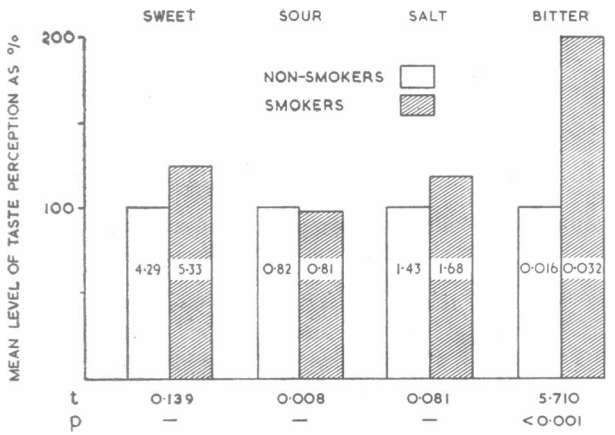

FIG. 1.—Combined student and insurance groups' mean threshold values for each of the taste primaries, comparing 79 smokers with 77 non-smokers. Note the significantly higher threshold among smokers for bitter only.

TABLE I.—*Mean Thresholds for Quinine Solutions in Relation to Age and Sex in Smokers and Non-smokers. Note that Allowing for Age and Sex Variables Does Not Affect the Finding that Non-smokers Have a Significantly Better Taste Acuity for Bitter than Smokers*

Class	Smokers		Non-smokers		t	P
	No.		No.			
All subjects (Mean age)	79	0·032 (25·6±9·5)	77	0·016 (22·0±4·9)	5·710	<0·001
Males only (Mean age)	66	0·032 (23·6±8·2)	54	0·017 (21·3±5·4)	5·017	<0·001
Males < 40 yrs. (Mean age)	61	0·031 (22·5±1·6)	54	0·017 (21·3±5·4)	4·684	<0·001
Females only (Mean age)	13	0·035 (33·6±13·4)	23	0·013 (22·5±5·6)	3·019	<0·01

Age in Relation to Thresholds for Bitter.—The mean threshold values in the non-smokers showed no significant change in considering the age-groups: under 20 years (0.016%), 20–30 years (0.014%), over 30 years (0.021%). On analysis of variance $P>0.2$. In the smokers, however, there was a progressive deterioration with age: under 20 years (0.026%), 20–30 years (0.034%), over 30 years (0.044%). Analysis of variance of the mean quinine thresholds in these age groups showed that this deterioration was significant ($0.05>P>0.01$) (Fig. 2).

Amount Smoked in Relation to Thresholds for Bitter.—The light smokers (not more than 10 cigarettes/day) had a mean threshold level of 0.027%. This was significantly less than the mean level (0.040%) in the moderate smokers (11–20 cigarettes/day) ($P<0.001$). There was, however, no further change in the mean level of those smoking more than 20 cigarettes/day (0.033%) ($P<0.4$). This mean threshold was also significantly higher than in the light smokers ($P<0.02$) (Fig. 3). Light smokers are thus less affected than moderate smokers, but there appears to be no further deterioration if more than 20 cigarettes a day are smoked.

Immediate Effects of Smoking.—In the 60 subjects tested it was found that there was on the whole a slight improvement in taste perception for the taste primaries in both smokers and non-smokers. None of these changes were, however, statistically significant, nor was the improvement in the smokers significantly different from that in the non-smokers (Table II). The smoking of a cigarette, then, had no immediate effect on taste perception.

Phenylthiocarbamide (P.T.C.)—Thresholds for this substance showed the classical bimodal distribution into "tasters" and "non-tasters" in both smokers and non-smokers (Fig. 4). The antimode of these distributions

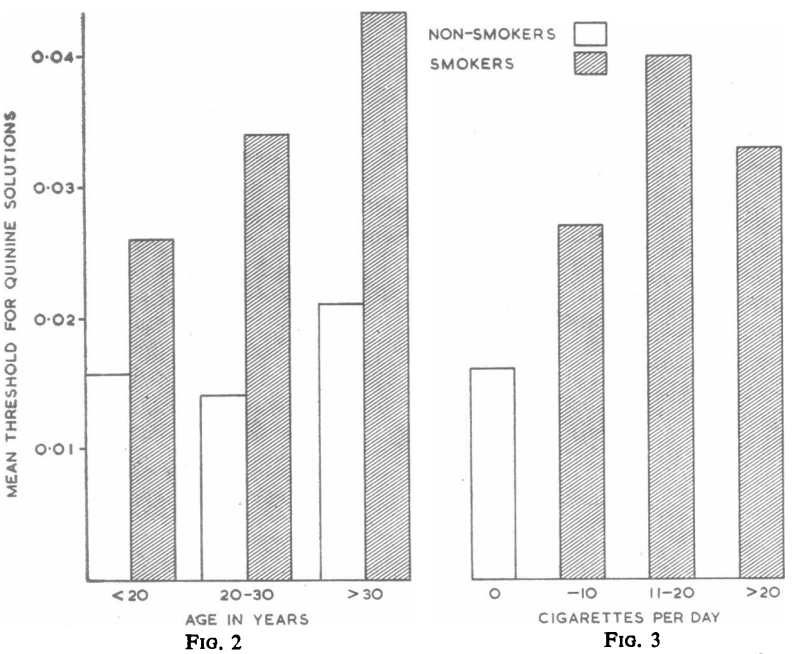

FIG. 2

FIG. 3

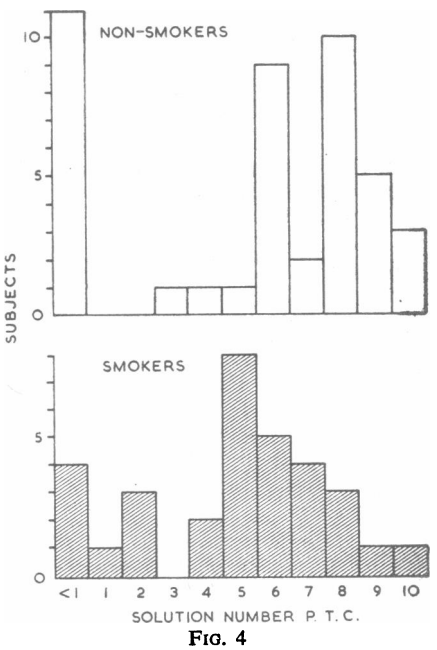

FIG. 4

FIG. 2.—Mean threshold for quinine solutions in relation to age level in smokers and non-smokers, showing a significant and progressive deterioration with age among the smokers only. This effect is thus attributed to the duration of smoking. FIG. 3.—Mean threshold for quinine solutions in relation to amount smoked. The moderate smokers showed a significantly higher threshold ($P<0.001$) than the light smokers. The threshold in the heavy smokers was not significantly different from that in the moderate smokers ($P<0.4$), but was significantly greater than in the light smokers ($P<0.02$). FIG. 4.—Number of subjects identifying the taste of P.T.C. as bitter at each concentration from 0.13 to 0.00025%, corresponding to solution numbers 1–10. Those subjects not identifying this taste from one drop are grouped under solution number <1 The antimode of these distributions is taken as being between solution numbers 2 and 3. The distribution between "tasters" and "non tasters" was the same in smokers and non-smokers on chi-square analysis ($P>0.9$).

is taken as being between solution numbers 2 and 3. Chi-square analysis showed that the distribution of smokers between "tasters" and "non-tasters" is the same as for non-smokers ($P>0.9$). Analysis of the P.T.C. tasters showed that in smokers the mean threshold was a titre of 0.0053%, whereas in the non-smokers it was lower (0.0034%). The difference, however, was not significant ($0.2>P>0.1$).

Discussion

It has been shown that the taste acuity of smokers for sweet, sour, and salt is not significantly different from that of non-smokers. The perception of bitter is, however, significantly worse in smokers (Fig. 1).

There are few reported studies with which to compare our results. As in our study, Richter and Campbell (1940) report that excessive smoking did not affect taste sensitivity for sucrose solutions. Cooper, Bilash, and Zubek (1959), in a study of the effects of age on taste, mention that in a sample of 58 smokers and 42 non-smokers from their subjects there were no significant differences in taste sensitivity for any of the taste primaries. Their technique, using a sipping method, did not ensure that a fixed amount of each solution was offered for tasting on each occasion.

Age has been shown to influence taste acuity, but not over age range (Harris and Kalmus, 1950–1 ; Kalmus, 1958 ; Cooper *et al.*, 1959). Sex has also been shown to influence taste in that females, as a group, are more sensitive (Falconer, 1946–7 ; Harris and Kalmus, 1950–1 ; Kalmus, 1958 ; Pangborn, 1959). This variable also cannot account for the difference in sensitivity to bitter between smokers and non-smokers, since, although there were more females among the non-smokers, their exclusion did not affect the results (Table I).

Unfortunately no record of the age of onset of smoking is available. Since, however, most persons start smoking in their late teens, the finding of a progressive deterioration in sensitivity for bitter among the smokers, but not the non-smokers, with increasing age (Fig. 2) is probably best explained by the effect of duration of smoking. The slight but non-significant changes in taste acuity on repeat testing in smokers and non-smokers (Table II) is a phenomenon reported on by others (Harris and Kalmus, 1950–1 ; Pangborn, 1959) and is attributed to learning. Certainly the immediate effects of smoking a cigarette are not responsible for our findings. It would thus appear that continued smoking progressively affects taste acuity for bitter.

The same finding in two separate unselected samples of subjects and the fact that the association was relative to the age of the smokers, and thus presumably the duration of smoking, as well as the amount smoked (Fig. 3), strengthens our conviction that this defective taste for bitter among smokers does exist.

The possibility that individuals with an inherently defective taste for bitter were more likely to become smokers was entertained. Fox (1932) discovered that all people, regardless of race, age, or sex, are divided into "tasters" and "non-tasters" of P.T.C., and that this character is genetically determined. This was shortly thereafter shown by Blakeslee (1932) to be not absolute, but to follow a bimodal distribution. Salmon and Blakeslee (1935) and Falconer (1946–7) found no correlation between smoking and taste for P.T.C. Our results, in showing the same bimodal distribution for both smokers and non-smokers (Fig. 4), concur with their findings. Falconer (1946–7) and Kalmus (1958) found that there was some correlation between thresholds for P.T.C. and quinine. We found that, while the non-smokers among the P.T.C. tasters were more sensitive that the smokers, the difference was not significant ($P<0.2$). It is therefore unlikely that the decreased acuity for bitter among smokers, as tested by quinine, arises on a genetic basis and we attribute it to the effects of smoking.

The possible explanation for the selective inhibition for bitter, and not sour, salt, or sweet, by smoking is speculative. El-Baradi and Bourne (1951) have shown by histological techniques that the alkaloid quinine strongly inhibits an esterase in the taste buds, suggesting that enzyme inhibition is the mechanism in taste perception. Nicotine and other alkaloids are abundant in tobacco smoke (Henry, 1949 ; Salter, 1952 ; Goodman and Gilman, 1955 ; Sollmann, 1957). It is conceivable that the alkaloids of tobacco smoke may act in a manner similar to quinine, and in this way possibly fatigue the mechanisms for perception of bitter.

Conclusions and Summary

In two completely separate population groups, a comparison of taste perception among samples of smokers and non-smokers revealed that the taste thresholds for bitter (using quinine hydrochloride) was significantly higher in smokers than in non-smokers. There was no significant difference in the taste thresholds for sweet, sour, or salt between smokers and non-smokers. Bitter is thus specifically affected. The age of the smoker, and thus presumably the duration of smoking, as well as the amount smoked, both adversely affected sensitivity to quinine solutions.

The smoking of a cigarette has no immediate effect on taste, for any of the taste primaries in smokers. Smoking, in decreasing sensitivity to bitter, appears to be the result of prolonged addiction to the habit.

As determined by P.T.C. testing, there does not appear to be a genetic inability among smokers to taste bitter.

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TABLE II.—*Comparison of Taste Thresholds for Each of the Taste Primaries immediately Before and After Smoking a Cigarette. The Non-smokers were Similarly Tested, Allowing the Same Time Interval Between Testing as in the Case of Smokers. No Significant Changes were found. The Immediate Effects of Smoking a Cigarette thus do not Influence Taste Acuity for any of the Taste Primaries.*

	Smokers (29)					Non-smokers (31)					(A)–(B)
	Before	After	Diff. (A)	t	P	Before	After	Diff. (B)	t	P	P
Sweet ..	6·21	5·06	−1·15	1·272	—	4·38	4·12	−0·26	0·659	—	—
Sour ..	0·954	0·866	−0·088	0·595	—	0·719	0·739	+0·020	0·049	—	—
Salt	1·94	1·78	−0·16	0·495	—	1·23	1·11	−0·12	0·003	—	—
Bitter ..	0·035	0·027	−0·008	1·526	—	0·016	0·015	−0·001	1·561	—	—

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SMOKING AND FOOD PREFERENCES

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It was of interest to determine whether the differences in taste perception that exist between smokers and non-smokers (Krut, Perrin and Bronte-Stewart, 1961) had any bearing on their food preferences. There is a belief that smokers do prefer more savoury foods, and that, with abstinence from smoking, sweeter foods are preferred, and this possibly accounts for the subsequent increase in weight that has been reported (Brožek and Keys, 1957). As these impressions are without any factual foundation, this study was planned to obtain data in this regard.

Material and Methods

The subjects of this study were sampled from two sources—a group of 80 second-year medical students and a group of 76 males and females from an insurance firm whose ages ranged from 17 years to 50 years.

Firstly, in a printed questionary the subjects, who consisted of 79 smokers and 77 non-smokers, were asked to indicate their preferences for salty, spiced, sour, or bland foods, examples of each kind being given.

Secondly, in conjunction with the questionary, a diet history was taken by the system of recall, paying particular attention to the fat content of the diet derived from common foods: 63 smokers and 62 non-smokers were questioned.

Finally, the male smokers (all smoking more than 20 cigarettes/day) and non-smokers, whose ages matched, were selected from the insurance personnel tested for taste sensitivity. Thus sex, age, and socio-economic background were matched so that the variable factors were limited so far as possible. From these men, two small groups, A and B, consisting of heavy smokers and non-smokers, were selected with the use of random number tables (Fisher and Yates, 1957) for a more detailed dietary investigation.

Nine smokers and eight non-smokers formed group A and eleven smokers and nine non-smokers group B. A detailed description of the daily diet was obtained, paying attention not only to the main meals but also to snacks, the variations during the week and week-ends, and the methods used in cooking. The amounts eaten were gauged on average portions, but if there were obvious deviations these were taken into account. The fat content of various foods was obtained from standard food tables (Fox and Golberg, 1944; McCance and Widdowson, 1946).

Results

Subjective Taste Preferences.—Of the 79 smokers who completed the questionary on their preferences for salty, spiced, sour, and bland foods, 36 said they preferred salty foods, 50 spiced food, 24 showed preference for sour food, while 40 preferred bland food. Of the 77 non-smokers, 29 preferred salty food, 39 spiced, 30 sour, and 61 bland food. The differences were significant for bland food ($P<0.001$), but for salty and spiced food combined ($0.1>P>0.05$) the result was not quite significant.

Semi-quantitative Dietary Survey.—The total fat assessed from common fatty foods came to a mean of 577 g./week for smokers and 543 g./week for non-smokers—that is, smokers ate a slightly more fatty diet than non-smokers. However, this brief history did not take into account all the fat eaten in the diet, and the results were not significant.

Detailed Dietary Surveys

In group A, smokers consumed 1,215 g. fat/week as compared with 1,094 g. fat/week for non-smokers, but this was not statistically significant ($0.5>P>0.4$). On more detailed examination, however, marked differences existed in the types of foods that constituted the overall fat intake in these two groups. Heavy smokers consumed significantly more meat and more eggs than did non-smokers, but non-smokers consumed somewhat more fat in the form of cakes, sweets, and chocolate.

Almost the same results were shown in group B—that is, the total fat was 1,155 g./week for smokers and 931 g./week for non-smokers. Similarly, heavy smokers consumed significantly more meat and more eggs than did non-smokers, but the intake of fat from other foods was again not very different (Fig. 1).

For the purpose of statistical analysis, group A and group B were combined and the results shown as a mean. The differences between smokers and non-smokers for meat and eggs were significant for these samples ($0.02>P>0.01$ and $0.05>P>0.02$ respectively). No statistically significant difference was seen in the